

## **APPENDIX 6: PHYTOLITH ANALYSIS**

# **PHYTOLITH ANALYSIS OF SELECTED SOIL SAMPLES FROM 31WA1137, WAKE COUNTY, NORTH CAROLINA (Dr. Irwin Rovner)**

## **INTRODUCTION**

Phytolith analysis was conducted on eleven soil samples from Neuse Levee (31WA1137). Phytolith analysis was employed to discover aspects of the ethnobotany, natural ecology, and climatic history of the site. Samples extended from the Late Archaic to Late Woodland periods.

Phytolith specimens were present in all samples, but assemblages were not homogeneous. Frequency ratios of grass short cells to sponge spicules provided clear evidence of a climatic sequence, beginning with a Middle Holocene warm and dry regime, changing to warm and wet by the Late Archaic, and reverting to warm and dry again by Early Woodland times.

Panicoid crossbody short cells provide a maize signature in four samples beginning with a stratigraphically early horizon, perhaps 6000 B.P. This is probably not a credible occurrence of maize but suggest that the current phytolith protocol for maize identification is unreliable.

## **SETTING**

Neuse Levee was on a levee on the north bank of the Neuse River 7.2 km below the Falls of the Neuse northeast of Raleigh, North Carolina (see Figure 2.1). As such it is in the transition zone between the North Carolina Piedmont and northern Coastal Plain. Ward (1983) and Phelps (1983) respectively provide extensive treatment of the cultural sequence in the two physiographic provinces. Byrd (1997), and Davis and Ward (1991), and Woodall (1991) provide important new insights regarding cultures of the Coastal Plains and Piedmont.

The Neuse River is recognized both among historical groups and among prehistoric antecedents as a cultural boundary across the Coastal Plain. This appears to be because the Neuse River enters the Atlantic Ocean at the break point between the highly embayed coast to the north (see Figure 1.1) and a much less complex coast to the south. The extensive embayments and coastal shallows of the embayed coast provide extremely rich coastal zone resources even at present. This rich environment seems to have stretched across the Coastal Plain at least as far as the Fall Line. The coastal shallows provided not only habitat for extensive and varied shellfish populations, but also transition zones for vast populations of anadromous fish. Anadromous fish such as shad and spotted bass are known historically to have provided a major component of northern Coastal Plain subsistence. Neuse Levee could have provided access to this harvest during prehistoric times. Terrestrially it also seems to have been on an early historic overland trail paralleling the Fall Line. Such trails normally followed prehistoric Native American paths. The location could therefore have been the intersection of both waterborne and terrestrial traffic during prehistoric times.

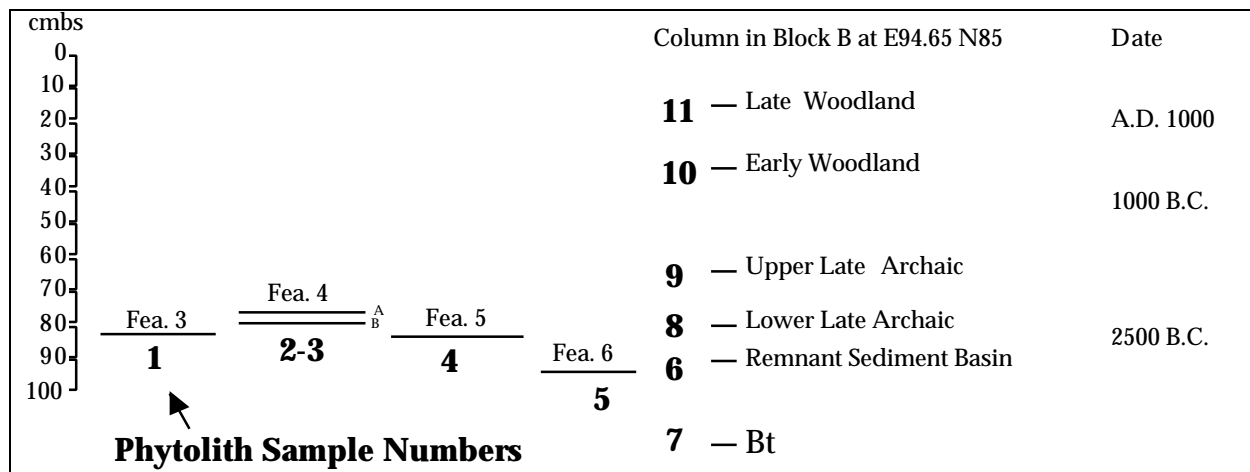
The Neuse Levee cultural levels reside on top of an eroded Early Holocene to early Middle Holocene levee. The culturally sterile sediments within the early levee are highly pedogenically altered forming a developed, thick Bt soil. A radiocarbon date on a nut shell fragment from near the basal gravels at 4.5 m returned  $10,160 \pm 80$  B.P., while another date on wood charcoal near the top (1.3 m) proved to be  $7270 \pm 60$  B.P. On top of the eroded Bt horizon is a series of Late Holocene strata about 1.1 m thick on the crest of the levee. Late Woodland ceramics are near the surface. Early Woodland indicators appear at about 50 cm below the surface, and a Late Archaic lithic occupation that incorporates a complex tool assemblage

and intensive use of local lithic materials lies virtually on the eroded Bt surface. A series of four radiocarbon dates at around 85 cm below the surface all clustered around 3800 B.P. The radiocarbon dates are not associated with cultural features, but the samples contained both wood charcoal and nut shells, which could indicate human association rather than natural sources.

Parallel to the phytolith samples discussed below, a series of sediment samples was taken for oxidizable carbon ratio (OCR) dates (Frink 1994). The dates provide a 10-cm-interval sequence through the cultural strata (see Figures 6.17 and 6.20). Examination of the relationship between the depth and age (see Figure 10.1) of the OCR dates suggests changes in deposition rates and in one case redeposition, or perhaps human intervention, in the soil carbon record. The OCR dates, with one exception, grade downward to 6053 B.P. The exception is just above the eroded Bt surface and could represent some kind of disruption of the carbon decay process, such as an episode of erosion and redeposition in the level. The OCR date at the unit 1–2 contact, the top of the Bt, cross checks reasonably well with the  $7210 \pm 60$  radiocarbon date in the upper part of the Bt horizon (see Chapter 2). The dates suggest an episode of slow deposition or erosion between the Late Archaic and Early Woodland that began at about 3000 B.P., at the beginning of the Early Woodland.

Deposition rates can be inferred from the OCR dates because of their concentrated numbers and thus their high resolution down the sediment column. If date samples are taken at equally spaced intervals, then the geometric relationships of the dates to each other and to the whole of the column, should have meaning relative to the rate of deposition of the sediments. For example, if the sediments are being deposited slowly over the course of a 10-cm vertical interval, then more time passes for the carbon to decay and the dates should be relatively far apart in time. In the time/depth plot (see Figure 10.1) this would result in a relatively flat angle of deposition. If, on the other hand, the deposition is rapid, then, the angle should be steep reflecting the increased rate of deposition during the 10-cm interval. A third relationship can be expected when redeposition dominates the sedimentation environment, which would appear as dates that are out of order in the time/depth column. In the time/depth column for Neuse Levee, all three of these relationships occur. In Stratum I an approximately  $45^\circ$  angle relates all four dates (B4–B19). Through Strata II and III the rate of deposition begins very rapidly (B56–B50), then decelerates from B46 to B26. Stratum IV contrasts with the overlying stratum by having an episode of redeposition near its bottom (B71), but then a normal deposition rate in its upper levels. The deposition rate in Stratum V is flattest and therefore slowest by these criteria. These deposition rates will be reconsidered below in evaluating the phytolith sequence.

Three columns of sediment samples were taken from Neuse Levee. The samples were removed from excavation walls in continuous columns of alternating levels of 5 cm and 1 cm (Figure 1). Samples were also taken from inside and outside features. A pattern of samples was selected from column 1 in the south block. The samples were chosen to investigate various lithologic and cultural strata.



**Figure 1. Relative Locations of Phytolith Samples and Their Numbers as Used in the Text.**

## PHYTOLITH METHODS

### Phytolith Extraction from Sediments

Conventional soil extraction procedures for all soil samples were initially used with modifications employed as required by the nature of specific samples. Standard procedures generally followed those found in Rovner (1971, 1983). The soil was initially “cleaned” to promote disaggregation of all particles—inorganic, organic and biolithic—as follows:

1. About 20 ml of soil placed into clean beaker.
2. Distilled water added, stirred, and either placed in a centrifuge at moderate speed for 20 to 30 minutes, or allowed to settle for a minimum of 4 hours. Piperno (1988) suggests one hour is sufficient for tropical soils. The additional time provided here was an arbitrary caution procedure given possible factors of soil differences. Only small to very small amounts of macrobotanical fragments, fibers, or particles were observed.
3. The aliquot with suspended fine particles and very light fraction material (e.g. floating rootlets, fibers, charcoal, etc.), was decanted and discarded.
4. To oxidize and eliminate sticky organic residues, the soil was treated with 5.25% sodium hypochlorite solution (i.e., commercial household bleach). This was successful, precluding use of concentrated hydrogen peroxide or nitric acid solutions, which are more difficult to handle and far less environmentally benign (with respect to disposal, for example.)
5. Following oxidation, soil samples were rinsed 2–3 times with distilled water, stirred, settled or centrifuged, and decanted.
6. Dilute HCl (20 ml) was added to each sample to remove carbonates. None of the samples reacted to the acid. Samples were allowed to settle, and the aliquot was decanted and discarded.
7. Each sample was rinsed three times with distilled water.

8. The soil was resuspended in distilled water to which a deflocculant (i.e., Calgon) was added to suspend very fine silt particles. After centrifuging or settling overnight, the aliquots with suspended fine particles were decanted and discarded. Step 8 was repeated as necessary, until aliquot was clean.

9. Soil was placed in a drying oven set at 90°C until dry.

10. Heavy liquid for flotation separation was prepared by dissolving zinc bromide powder in slightly acidified distilled water until a specific gravity between 2.3 and 2.4 was achieved. This was easily determined using a commercial calibrated hydrometer.

11. Approximately 5 ml of dry soil was added to heavy liquid in a bent, clear tygon tube which was squeezed gently to wet the soil. The bent tube was inserted into a lightly greased centrifuge shell and centrifuged at moderate speed for 30 minutes to float phytoliths.

12. After centrifugation, clamps were placed on both vertical arms of the bent tube just below the floatant surface in the tube. A stream of water from a wash bottle was used to rinse the floatant from the tygon tube into a 50 ml centrifuge tube.

13. Distilled water was added to the centrifuge tube to about 40 ml level. Centrifugation precipitated the phytoliths. The aliquot was decanted. This step was then repeated.

14. Phytoliths were then decanted to a shell vial and placed in a drying oven to remove excess liquid.

### **Microscope Scanning**

The phytolith extracts were quick-mounted in distilled water and viewed in an optical microscope at 400x. Mounts were prepared by pressing a slide over the mouth of an open vial, which was then inverted. The extract was allowed to settle on the slide, the vial was reverted to its original orientation, and the slide was quickly removed, retaining a drop of fluid with a portion of extract included.

Whole slides were scanned at 100x to find clusters of particles, which were then scanned at 400x to determine the character of individual particles. Representative and especially taxonomically significant phytoliths and other biosilica bodies (e.g., diatoms and sponge spicules) in each slide mount were noted. After all samples were initially scanned, second slide mounts were made and scanned to obtain particle counts, which are provided in Table 1. Panicoid crossbodies, the critical type for determination of the presence of maize, were measured using the microscope eyepiece micrometer, and then were videotaped. Videotaped images were digitized for image processing and analysis, with morphometric data of size and shape taken.

### **Compilation and Interpretation of Data.**

No phytolith reference data base developed from phytolith extracts of living plants in the site's region was available or specifically prepared for this study. This lack severely limits taxonomic specificity in interpreting phytoliths present and, predictably, leaves a substantial number of morphologically distinctive (and sometimes frequent) phytolith types classified as "unknown". However, recent publications, especially Rapp and Mulholland (1992), provide substantial verification for both general and specific taxonomic assignments of phytoliths.

In the absence of a regional phytolith database, published typological information was employed for classification of phytolith types. For grasses, the three-tribe classification of Twiss et al. (1969) includes:

- Festucoid (wet, cool habitat),
- Panicoid (wet, warm habitat) and
- Chloridoid (dry, warm habitat)

These phytolith classes are the conventional standard, along with elaborations by Brown (1984).

For angiosperms (e.g., deciduous trees and shrubs) and conifers, Geis (1973), Klein and Geis (1978) and Rovner (1971) provide some guidance for eastern woodland flora content. The most elaborate work to date in these taxa has been done by Japanese experts (Kondo 1974, 1976, 1977; Kondo and Pearson 1981; Kondo and Sase 1986; Kondo, et al. 1987), primarily on Asian flora. However, considerable similarity of illustrated phytolith forms at the genus level between American and Japanese plants provides confident guidance in the taxonomic assignment of distinctive phytoliths in these categories. Most recently, studies by Bozarth (1992) and Cummings (1992) have confirmed and refined the typology and taxonomy of phytoliths in dicotyledonous taxa. Distinctive material can now be attributed specifically to Asteraceae (Compositae), a dicotyledonous group well represented and ethnobotanically significant in the eastern United States. While soil phytolith studies in the general region of the mid-Appalachians and Atlantic seaboard are few in number, general comparisons can be drawn from studies at such eastern historic period sites as Monticello, Virginia (Rovner 1988a); Hampton, Virginia (Rovner 1989); Harpers Ferry, West Virginia (Rovner 1994); Jordan Site (31NH256), North Carolina (Rovner 1984); and 31MK683, North Carolina (Rovner 1995a, 1995b). Moreover, the number of sites tested in this region is increasing and recent reports (Rovner 1997; Owens and Rovner 1997) provided a basis for general patterns of land use and botanical history for the seventeenth through nineteenth centuries, in conjunction with archaeological history.

## RESULTS

All samples produced mostly well-preserved phytolith assemblages but with markedly differing quantities (Table 1). Notably, several instances of mechanically broken phytoliths along with large fragment sections were observed commonly throughout the sequence. Non-grass phytoliths were frequent along with the commonly occurring “truncated” assemblage of large grass-type particles, bulliforms, squares, and rectangles; the latter is typical of alluvial soils. Such an assemblage was common, if not dominant at the three Wakefield Plantation sites (Rovner 1998). However, in marked contrast to the Wakefield samples, grass short cells were common in many of these assemblages, providing critical taxonomic information not available from assessment of large grass phytolith assemblages. Panicoid (wet, warm) lobate phytoliths dominated overwhelmingly, sometimes exclusively, over festucoid (wet, cool) and chloridoid (dry, warm) types. In addition, sponge spicules were present in almost all samples, often in great abundance, with diatoms rarely present.

**SAMPLE 11: Late Woodland:** A very rich and abundant assemblage of phytoliths was found in sample 11 (see Figure 1), including a wide range of non-grass phytoliths-hairs, plates, cellular epidermes, globules, cell casts, silicified tracheids, etc. Grass phytoliths were likewise rich and abundant, with a distinct dominance of panicoid lobates, including crossbodies, some of which were large enough to derive from maize. Both festucoid and chloridoid short cells were well represented. Likewise, sponge spicules were common and diatoms were proportionately more frequent in this sample than in any other, even allowing for sample size differences.

**Table 1. Counts of Grass Short Cell Phytoliths and Aquatic Bioliths with Indexes of Grass to Aquatic Biolith Ratios.**

Sample	Panicoid	Festicoid	Chloridoid	Sponge	Diatom	Grass/Aqu.	Pan./Spng.
11	72	17	11	32	8	2.5	2.25
10	52	3	6	62	1	0.97	0.84
9	6	1		12		0.58	0.50
8	13	1	1	28		0.54	0.46
7	19		5	15		1.60	1.23
6	47	6	10	81		0.74	0.58
5	7			5		1.40	1.40
4	60	5	5	96	1	0.72	0.625
3	10	1	1	29		0.41	0.34
2	20	2	1	31	1	0.72	0.65
1	18	2	4	51		0.47	0.35

SAMPLE 10: Early Woodland: This was also a very rich sample, and similar in general to Sample 11, although subtle differences are present. The range of both grass and non-grass phytoliths is somewhat less. For instance, the total number of grass short cells is lower than in Sample 11, which could simply be mounting error. However, festuroid and chloridoid frequencies, (i.e. percentages), are lower in proportion to panicoid short cells, while sponge spicule frequency is higher but diatom frequency is lower. Thus, in spite of general similarities, there appear to be significant differences between Samples 10 and 11.

SAMPLES 9 and 8: Upper and Lower Archaic. Both samples are quite similar: sparse to moderate in phytolith quantity and range. This is not due merely to depth inasmuch as lower samples, such as Samples 6 and 4, are much richer and similar to Sample 10 in abundance. Short cell counts are much lower, yet both similarly reflect a rather high sponge spicule ratio as an indication of wetness.

SAMPLE 6: Remnant Sediment Basin. This sample was rich and abundant, similar in quantity and range to Sample 10, but less than 11.

SAMPLE 7: Bt horizon. Rather sparse to moderate, Sample 7 was similar in quantity to Samples 8 and 9. However, this sample is significantly different from Samples 6, 8, and 9, given a notable reduction in the proportion of sponge spicules. This is probably indicative of early drier conditions compared to the Archaic period samples above.

SAMPLE 5: Feature 6. By far this was the most impoverished phytolith assemblage. There were few grass short cells and fewer sponges. In the first mount scanned only one panicoid short cell and two sponges were observed. Sponges are large and distinctive and very difficult to miss; thus their absence is probably not due to sampling error. Counts, presented in Table 1, required scanning two mounted slides to produce even these low numbers. With all due consideration to small sample size error, this sample has a low sponge ratio, indicative of relative dryness. In this regard, it corresponds most closely to Sample 7.

SAMPLE 4: Feature 5. This was a rich and diverse phytolith assemblage, similar to Sample 6, and 10. It contains the full range of non-grass and grass phytoliths, including all three grass tribes of short cell types as well as crossbodies, many sponge spicules, etc. Mechanically broken phytoliths were also common. Particularly noteworthy is the clear difference with Sample 5. Both Feature 5 and Feature 6 are characterized culturally by the presence of primary lithic debitage. Phytolith data clearly shows substantial differences in other contextual parameters.

SAMPLE 3: Feature 4B. This was a moderately rich and dense assemblage showing the full range of grass and non-grass phytoliths, including broken particles indicative of a wet context. Numerically, according to the panicoid short cell to sponge ratio, this is the wettest context in the sequence. It is similar to Samples 4, 6, and 10, and different from Samples 7 and 5 in this regard. It is also distinct from Sample 4A, strongly suggesting that the upper and lower deposits of this feature were derived from very different edaphic regimes.

SAMPLE 2: Feature 4A. This phytolith assemblage is relatively sparse. While most of the typical general categories of grass and non-grass phytoliths, along with sponges, are present, grass short cells outnumber sponges, suggesting a drier regime in contrast with Sample 3 from lower in the same feature. Sample 2 is similar to stratigraphically older Samples 7 and 5. Lower Sample 3 is similar to stratigraphically younger Samples 6 and 10. These findings support the suggestion of reverse stratigraphy in the feature itself.

SAMPLE 1: Feature 3. This sample was sparse to moderate assemblage. Although the counts are relatively small, the wet/dry index is strongly in favor of wetness, second only to Sample 3 and similar to other wet samples such as 8 and 9.

## DISCUSSION

### Specific Research Issues

General Conditions of the Watershed. In general, phytolith data support the conditions expected in the flood plain of a major river. In all samples non-grass particles and sponge spicules were relatively frequent. Grass phytolith populations were dominated by the bulliform-rectangle-square, large-sized phytolith group associated with alluvial deposits, for example, at Harpers Ferry, West Virginia (Rovner 1994) and Wakefield, North Carolina (Rovner 1998). The common presence of broken bulliforms, broken rectangles, etc., even many “half-lobates”(panicoid dumbbells forms broken at the narrow “waist”) suggested some rather severe flooding activity, causing mechanical breakage of these robust and durable particles.

In spite of clear evidence for soil movement (including phytolith content) through such activities as flooding and alluviation, the phytolith assemblages were far from homogeneous. Samples ranged from quite rich to rather impoverished, both in the stratigraphic column and among the Archaic-period feature samples. Thus, it is clear that the phytolith assemblages were modulated by a number of factors, rather than mere depth or age, possibly including small-scale differences in location, hydrology, topography, floral cover, and/or cultural activities. Unfortunately, there is no convenient way to elucidate this from taxonomic classification of the phytoliths, especially in the non-grass category for which there is grossly inadequate systematics. In the grass category, the dominance by Panicoid short cells precluded effective use of conventional panicoid-festucoid-chloridoid ratios (Table 2). In all samples panicoid short cells provide more than 70 percent of the total. Too many of the samples have a small sample of the festucoid and/or chloridoid category, –Samples 2, 3, 5, 8 and 9, nearly half the study (see Table 1). An increase of only 1 or 2 Festucoid or Chloridoid particles in the absolute count could inflict a substantial percentage change in these cases, while a change of three particles in an appropriate category could change the entire profile of the sample. Reliance on such inadequate data is suspect and therefore rejected.

As an alternative to a purely grass short cell index for sample comparison, a new index was devised and applied: the ratio of grass short cells (the “terrestrial factor”), to sponges and diatoms (the “aquatic factor”) (see Table 1). The assumption is that in this comparison grasses represent relative dryness, while sponges (and diatoms) represent relative wetness. Given the dominance of panicoid short cells in the



terrestrial category and sponges over diatoms in the aquatic category, it made little effective difference in the results if “all grass” or “panicoids only” were used. Likewise, it made little difference if “all aquatic bioliths” or “sponges only” were used in the calculations. Substantial differences in sample index values were obtained, with emerging patterns suggesting high potential significance for interpreting small-scale and large-scale conditions in both space and time.

**Table 2. Percentages of Grass Short Cells According to Grass Tribe.**

Sample	Panicoid	Festucoid	Chloridoid
11	72.0	17.0	11.0
10	85.2	4.9	9.8
9	85.7	14.3	0
8	86.7	6.7	6.7
7	79.2	0	20.8
6	74.6	9.5	15.9
5	100.0	0	0
4	85.7	7.1	7.1
3	83.3	8.3	8.3
2	87.0	8.7	4.3
1	75.0	8.3	16.6

The uppermost sample, Sample 11, was extracted from the second level to avoid potential modern contamination. It is possible that this was not completely successful. A high percentage of festucoids is a frequent indicator of the arrival of European settlement, expressed quite clearly in the phytolith record from early in the Historic colonial period (Rovner 1997). In addition, in purely natural floral assemblages, festucoid grass is a cool-wet indicator by itself, which should correlate positively with sponge frequency. Since the high festucoid count occurs in the face of the decidedly lowest wetness index value of all the samples, some Historic-period European grass introduction is possible.

Sample 10, dating to the Early Woodland, shows a relatively high dryness index value for the sequence. Whether the reason is a general climate change toward decreased rainfall (and/or higher temperature) or topographic factors slowing overbank flooding, the trend is from a high wetness signature in Samples 8 and 9, to an intermediate dry value in Sample 10, to a very dry value in Sample 11.

Samples 8 and 9, which span the transition from Middle to Late Holocene, are quite similar in quantity and quality of phytoliths. Both are relatively sparse, with low grass short cell and sponge counts, and both have virtually identical wet-dry index values. The phytolith evidence, then, indicates no significant difference between these two samples, suggesting climatic stability rather than change. However, a sharp contrast with Sample 6, below, suggests that a substantial climatic or edaphic change occurred somewhat earlier. Inasmuch as Sample 6 is at the same depth as the anthropogenic Archaic features, the possibility is raised that climatic conditions fostering human occupation in the Sample 6 era were substantially influenced by a marked increase in rainfall at the beginning of the Late Archaic period.

The five samples from the four features (Features 3, 4, 5, and 6) are not homogeneous even though the radiocarbon dates are nearly identical in age (see Chapter 10). Sample 5 from Feature 6, the deepest of the features, has an impoverished phytolith assemblage overall. Although small sample size must be considered as a cautionary note, a relatively high dryness index of 1.4 places this sample ecologically close to the early dry period of the Bt level, Sample 7, rather than the wetter index levels of stratigraphic Samples 6, 8, and 9, above. Sample 4 (Feature 5) and Sample 2 (Feature 4A, upper level ) have similar intermediate index values, in marked contrast to Sample 3 (Feature 4B lower level) and Sample 1 (Feature 3), which share virtually identical, very wet index values. This pattern suggests a climatic seriation of samples: the upper level of Feature 4 (Sample 2) and Feature 5 (Sample 4) occur after the

drier Bt Sample 7 (and dry Feature 6, Sample 5), but before wetter stratigraphic Sample 6. The lower level of Feature 4 (Sample 3) and Feature 3 (Sample 1) then are the youngest features, related to the increased wetness seen in higher stratigraphic column Samples 6, 8, and 9. This makes the lower sample of Feature 4 younger than the upper sample of this feature, which is possible only in a case of reverse stratigraphy (i.e., the upper fill in the feature was taken from an earlier, drier soil horizon nearby and redeposited).

In broad outline, the lowest, earliest (Middle Holocene) Bt Sample #7 begins the sequence under a relatively dry regime. Feature 6 is the driest and thus climatically earliest of the features. Increased, intermediate-level wetness occurs in Features 5 and 4A, which are similar to Remnant Sediment Basin Sample 6. Further increases in wetness occur in Feature 3 and Feature 4 and continue through the Late Archaic period, as seen in Samples 8 and 9. The climate reverts to relative dryness by the Early Woodland period, as indicated in Sample 10.

This sequence of climatic instability is consistent with suggested patterns for the eastern Middle to Late Holocene, especially as observed in emerging phytolith data. Phytolith sequences from stratigraphic profiles encompassing the Archaic period at North Carolina site 31MK683 (Rovner, 1995a, 1995b) show a sudden appearance of panicoid short cells coincident with the Middle Archaic Period. This was initially seen as an increase in temperature, with rainfall effects unknown.

Evidence for a widespread Middle Archaic warming trend of unknown duration is startlingly clear in the phytolith record. This warming trend coincides well with the Atlantic Climatic Period, a decidedly warm and dry period. Its effect in the eastern Woodlands, according to the phytolith data, may have been more subtle, i.e. *warmer, but not necessarily drier*. This is not the first report of phytolith data suggesting such a warming trend. A phytolith study by Carbone (1977) of the Fifty Site and the Thunderbird Site in the Shenandoah Valley of Virginia reports similar climatic shifts during the Middle Archaic Period.

...[I]n these eastern forest archaic sites, the grass assemblage, if not the very presence of grass itself, results from local modulation caused by human campsite activities in the immediate area of the sites, respectively—local clearing of trees causing small openings in the canopy inviting pioneer weeds, such as grasses, to the immediate vicinity. Such local modulations would have little overall effect on the general pollen rain profile which would continue to show overwhelming dominance of arboreal flora in the region. Any resulting changes in pollen frequency would be statistically trivial and probably hidden below the random noise level in a pollen profile. On the other hand, decay-in-place phytolith frequencies can be significantly changed by these modulations in a specific microecology, such as within the boundaries of an archaic campsite.

...[T]rees as long term perennials are far less sensitive to subtle changes in local climate than are annual plants like pioneer weeds. Pollen rain derives largely from perennial trees while the grass phytoliths, such as in the studies presented here, can exhibit a clear reflection of the nature of pioneer annuals. The effects of Middle Archaic Period warming may not have been long enough or strong enough to modulate tree assemblages sufficiently, *especially if rainfall continued at substantial levels in the region* (Rovner 1996; Emphasis added).

Phytolith data from Neuse Levee, given the dominance of panicoid short cells in all samples, do not provide a basis for detecting the trends noted at these other eastern sites. However, this is the first site to provide phytolith evidence for increased wetness beginning in the Late Archaic Period of the Eastern United States, an idea suggested by Rovner (1996).

Although the number of phytolith profiles studied to date in this region is meager, the emerging phytolith pattern is consistent with regional pollen evidence. Kellogg and Custer (1994) summarized a series of

pollen studies from Delaware. They note a change from drier to wetter conditions around 6000 B.P., reverting to drier conditions after 2000 B.P.

During the last ice age, spruce and fir trees grew in Delaware under a cold, wet regime. Melting of the ice sheet brought warmer and drier conditions to the region. The environment became so dry that after 12,000 BP Walter's Puddle dried up completely. No mud or pollen was deposited in the pond until after 6000 BP when water again stood in the depression. Because the dryness caused a gap in the accumulation of mud in the lake there is not a record of the environments between 12,000 and 6000 BP at Walter's Puddle.

After 6000 BP the climate of central Delaware was wetter and mud and pollen accumulated in Walter's Puddle again. . . .

...[T]ranssects of cores across four bay/basins, including additional cores from Walter's Puddle [were used to] determine if the dry interval at Walter's Puddle was due to climate, and to determine the length of the dry interval. All four basins had a gap in sedimentation, therefore, local hydrological conditions can be ruled out. . . .

...[P]ollen studies...were [conducted] on [marsh] cores dating to the last 5000 years—after the dry episode documented by the study of the bay/basins. The oldest vegetation data in the marsh cores comes from pollen in Leipsic River core LR-1 and dates to about 5000 BP. As suggested by the pollen from Walter's Puddle, oak and pine forests dominated the landscapes at the time. . . .

The marsh pollen data suggests a wetter (and perhaps colder) interval sometime between 3000 and 2000 BP. Another dry interval followed. (Kellogg and Custer 1994:96–8)

Similar general climate shifts are provided in a summary of pollen evidence for the southeastern United States by Delcourt and Delcourt (1995).

During the early-Holocene interval, the rapid northward migration of cool-temperate, mesic tree species was followed by their expansion in dominance throughout the mid-latitudes of the southeastern United States. . . . From sites with continuous records of sedimentation spanning the time interval from about 12,500 to 8,500 B.P. . . . it is evident that the forest communities of the early-Holocene period differed in species composition and dominance from those that developed in the middle- and late-Holocene intervals. . . . The modern floristic region thus became defined at 34° N latitude only in the middle- to late-Holocene intervals as climatic conditions there shifted from cool-temperate to warm-temperate. (Delcourt and Delcourt 1995:19)

. . . . [I]n the southern Appalachian Mountains and the northern Gulf Coastal Plain, middle-Holocene vegetation reflected warm but wet regional climate. By 5,000 B.P., coastal-plain species characteristic of wetland environments had dispersed successfully into sag ponds in the Ridge and Valley of central Alabama and northwestern Georgia. In Cades Cove, Great Smokey Mountains National Park, East Tennessee, a woodland-hollow pond formed between 7,000 and 6,500 B.P. . . . This restricted and poorly-drained environment at 500 m elevation in the mountains today harbors numerous species characteristic of southern coastal plains. The pollen sequence from Lake in the Woods indicates that coastal-plain taxa had migrated into Cades Cove by 6,500 B.P. during a period of warm, wet climate and have persisted there to the present time. (Delcourt and Delcourt 1995:20)

Phytolith evidence from Neuse Levee extends this long-term, warmer, wetter period further to the north and east into the Carolinas.

The change to warmer and wetter conditions is apparently not consistent throughout the eastern United States, since pollen and some phytolith evidence suggest that conditions were different west of the Appalachian Mountains.

In the Midwestern United States, the middle-Holocene or Hypsithermal Interval was marked by the eastern expansion of prairie at the expense of forest. The effects of Hypsithermal warming and drying extended into the mid-latitudes of the Southeast west of the Appalachian Mountains; in Middle Tennessee, forest communities became species-poor and xeric between 8,500 and 4,000 B.P. (Delcourt and Delcourt 1995:19–20)

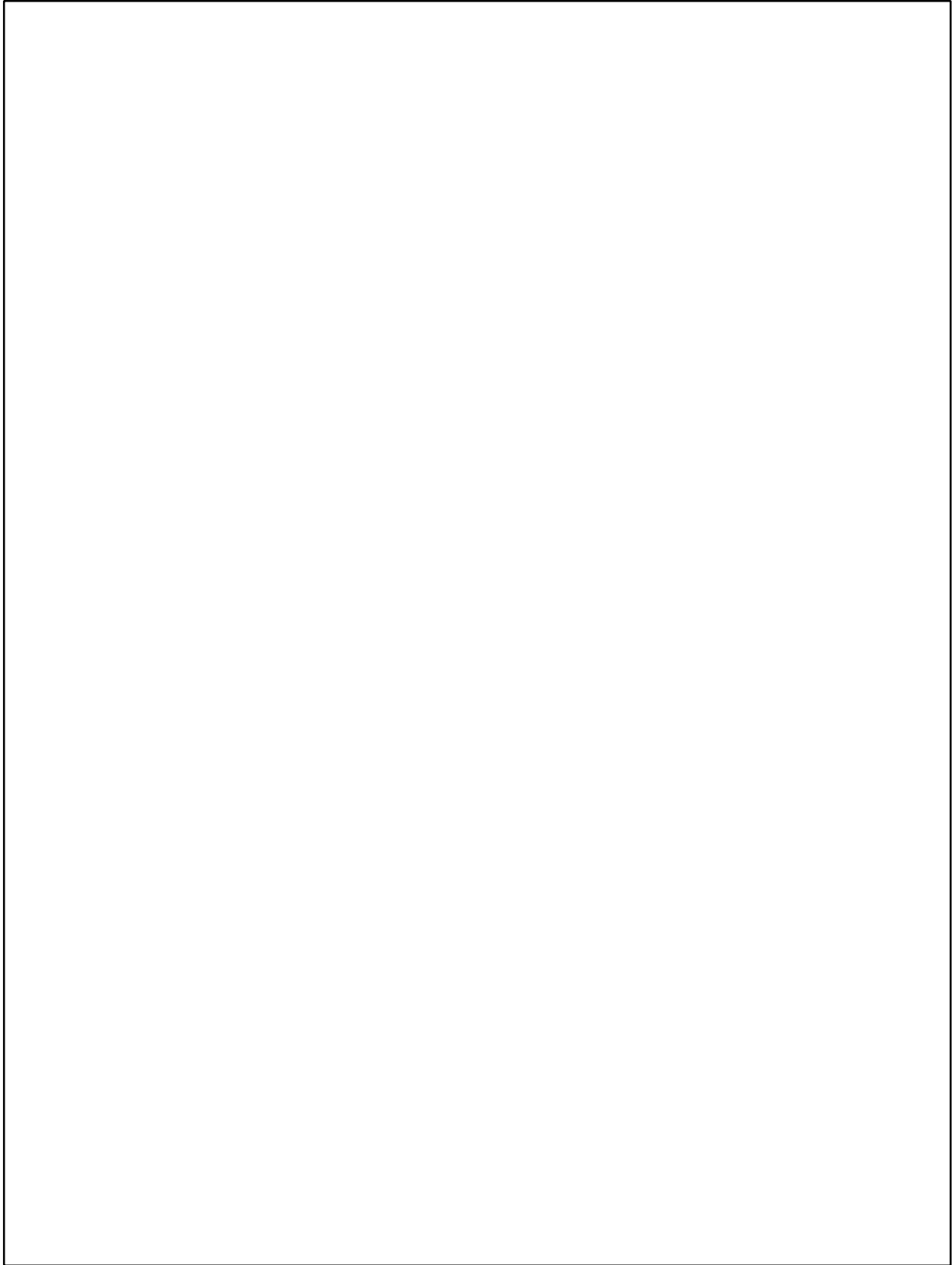
Unfortunately, phytolith data for the mid-Holocene in the region west of the Appalachians are virtually nonexistent. Some 25 years ago Rovner (1975) tested a long soil column from the Koster Site, Greene County, Illinois, for the Center for Archaeological Research. The goal was to determine the quality of phytolith preservation for future study of the full range of Holocene environments in the region (Rovner 1975). Although the test was successful, with abundant populations of well-preserved phytoliths in all cultural levels, only one formal follow-up study occurred. Soil samples from the intensively occupied Koster Middle Archaic Horizon VI were restudied in light of the controversial report of the recovery of maize pollen in this level (James Shoenwetter, personal communication, 1975). The Horizon VI phytolith assemblages were noted originally to contain notably high levels of panicoid short cells, providing a test of the maize identification procedure first reported by Pearsall (1978). The high frequency and overwhelming dominance of panicoid short cells were confirmed, but the application of Pearsall's procedure failed to yield an identification of maize, leaving the maize question unresolved. However, Hypsithermal warming and the migration of prairie grasses eastward obviously provide a compelling alternative explanation for these Horizon VI phytolith assemblages.

The climatic effects of the Late Holocene are particularly significant in comparing responses of Archaic peoples in their respective regions. West of the Appalachians, a warmer and drier climate caused upland forest communities to become “species-poor and xeric”, which may have forced people to utilize the valley bottoms more intensively. The increased population and intensive occupation at Koster Horizon VI may not have resulted voluntarily from increased knowledge and more efficient use of resources over time, but as a response to significant climatic change. This is a variation on the long-standing “Oasis Theory” of demographic shift and adaptive response to climatic change, although Horizon VI Koster may have no direct bearing on the question of agricultural origins in the Illinois River Valley (or anywhere else). However, it does represent a case in which marginal upland zones provide donor populations, increasing the population of the lowland optimum zone—a clear reversal of the Binfordian Optimal-Marginal Zone demographic model of Incipient Agriculture.

The Neuse Levee Bt horizon and the other grassland indicators at other sites cited above may suggest similar conditions east of the Appalachians.

Anthropogenic Factors and Identification of Maize. Patterns of ethnobotanic activity are not apparent in the assemblages. Differences in the phytolith content of the samples, whether comparing feature samples to each other or to the stratigraphic samples, appear to result from edaphic and climatic factors, rather than from human activity. Unexpectedly, four samples (11, 10, 7, and 4) produced distinctive panicoid lobate short cells of the crossbody type (Figure 2) in a size range that indicates domestic maize (Table 5), according to the protocols developed by Pearsall (1978, 1989) and Piperno (1984, 1988). Many other North American sites including some of comparable age, region, culture, etc. have failed to provide such indications in spite of substantial phytolith assemblages. Even in instances where the presence of maize was certain and phytolith patterns based on contextual parameters were strongly indicative, the Pearsall and Piperno taxonomic protocols based on morphological parameters failed to appear. This has led to a

general questioning of the reliability and validity of the taxonomic protocols as currently proposed (Rovner 1995d).



**Figure 2. Phytoliths from Neuse Levee.**

Accordingly, the evidence for large maize crossbody phytoliths at Neuse Levee extends from the Late Woodland Sample 11, the youngest in the stratigraphic sequence where evidence of maize is likely, to the very bottom of the stratigraphic sequence (Sample 7), where the presence of domestic maize would make it one of the earliest occurrences anywhere in the New World, a virtual impossibility. While this does little to elucidate factors relevant to the interpretation of the site itself, it does have critical bearing on the controversial issue of the reliability of the Pearsall and Piperno method of maize identification using phytoliths. This has major implications for study of agricultural origins, development, and distribution — not only in Southeastern archaeology but throughout Western Hemisphere prehistory.

Environmental conditions affect size variation in phytolith populations from one year or one place to the next, but shape remains stable (Ball 1992; Ball et al. 1997). Phytolith size difference is by itself not definitive proof of domestic versus wild taxa. The classification methods developed by Pearsall and Piperno to identify domestic maize use size parameters in highly questionable ways. Increased size of phytoliths in domestic maize is supposed to distinguish it from wild grasses (Pearsall 1989), but archaeological phytoliths offered as evidence of domestic maize in earliest Valdivia I and II (Pearsall 1989:332, Table 5.2) are larger than that for every modern maize tested. Either there is systematic error operating in the analysis, or we must accept the bizarre explanation that the earliest primitive maize in South America is more modern in its phytolith content than is modern maize currently grown in the region.

Pearsall tested effects of high temperature dry-ashing to extract phytoliths from reference plants, noting that significant shrinkage (sic) occurs, but not enough to confuse maize with wild grasses. However, comparisons of size values for modern maize phytolith populations (Pearsall 1989:376, Table 5.7; see Table 3) show that dry-ashed populations are far more likely to produce a larger size value than that from low temperature chemical oxidation—as much as 300% to 400% larger in specific cases. Pearsall's own data are self-contradictory and indicative of systematic error.

**Table 3. Deviation in Percent of Large Crosses in Maize (after Pearsall 1989).**

645	Canguil (ashed)	6.2
E7	Canguil (peeled)	14.7
646	Canguil (ashed)	22.8
E6	Patillo (peeled)	15.4
E8	Patillo (peeled)	50.0'
662	Patillo (ashed)	67.3
E3	Sabanero (peeled)	12.1
643	Sabanero (ashed)	39.1

Some systematic error probably derives from protocols for capturing specific phytolith forms for analysis. Only lobate short cells whose lengths are no more than 9 microns greater than measured width are captured regardless of absolute phytolith size. All others are ignored. The limit of 9 is always used regardless of absolute phytolith size. Thus, a shape measuring 27 by 18 microns is captured, but the identical shape measuring 30 by 20 microns is rejected. The rectangular shape measuring 18 by 9 is captured, but, if 20 by 10, it is not. This results in inconsistent capture bias according to particle shape, the environmentally stable parameter. S. Mulholland (1990) tested this protocol on an Old World Arundinoid reed grass and obtained a maize identification. Pearsall (1990) dismissed this finding as inconsequential because the Old World grass tested cannot appear in New World archaeological deposits. This may be true; but systematic error, morphological bias, and questionable analytical protocols can occur anywhere.

Table 4. Environment and Crossbody Size Stability (after Piperno 1988).

<i>Opismenus hirtellus</i>	% Variant 1	% Variant 6		
Panama	28	72		
Mexico	0	100		
		<b>mean width</b>	<b>width range</b>	
Panama		13.4	11.2–15.1	
Mexico		14.9		
		<b>% cross</b>		
Panama		4.5–8.5		
Mexico		12.5		
<i>Paspalum plicatulum</i>		<b>Variant 6</b>		
		<b>mean width</b>	<b>width range</b>	
Panama		11.4	10.8–12.1	
Mexico		10.5		
		<b>% cross</b>		
Panama		23–39		
Mexico		20		
<i>Cenchrus echinatus</i>				
	<b>Variant 1</b>		<b>Variant 6</b>	
	<b>mean width</b>	<b>width range</b>	<b>mean width</b>	<b>width range</b>
Panama	13.7	13.3–14.0	12.7	12.3–13.3
Belize	15		13.6	
	<b>% cross</b>			
Panama	29–51			
Belize	20			
<i>Axonopus compressus</i>	<b>Variant 1</b>		<b>Variant 6</b>	
	<b>mean width</b>	<b>width range</b>		
Panama	11.5	11.2–12.0		
Belize	10.4			
<i>Hymenache amplexicaulis</i>	<b>Variant 1</b>			
	<b>mean width</b>	<b>width range</b>		
Panama	10.9	10.5–11.3		
Mexico	11.7			
	<b>% cross</b>			
Panama	9–28			
Mexico	33			

Table 5. Size Distributions of Maize Range Crossbodies from 31WA1137.

Figure 1 Eyepiece	Size	Manual	Size	Prism Breadth	Size
A	18.7 x 16 large	18.58 x 14.18	medium	13.38	medium
B	18.7 x 16 large	18.15 x 14.80	medium	14.73	medium
C	40.0 x 32 superlarge	37.74 x 30.81	superlarge	29.77	superlarge
D	21.4 x 21.4 very large	19.00 x 18.18	large	18.4	large
E	21.4 x 21.4 very large	20.84 x 19.01	large	18.3	large
F	18.7 x 18.7 large	16.99 x 15.96	large	16.1	large
G	21.4 x 18.7 large	20.62 x 17.23	large	17.04	large
H	18.7 x 16 large	15.92 x 15.58	medium	14.84	medium
I	26.7 x 24 very large	21.96 x 21.94	very large	18.14	large
J	18.7 x 16 large	19.01 x 16.67	large	15.89	medium
K	16.0 x 16.0 large	15.03 x 14.02	medium	13.68	medium
L	21.4 x 18.7 large	19.47 x 16.42	large	15.6	medium



## CONCLUSIONS

The phytolith data from Neuse Levee (31WA1137) add significant new information to the history of Holocene climate and climatic change for the region, with substantial implications for cultural history and human adaptation in prehistory. The Hypsithermal was indeed a period of general warming, which has received recent confirmation through phytolith analysis of Archaic-period sites in the eastern United States. Neuse Levee provides phytolith evidence indicating that rainfall patterns in the region were more complex. Pollen evidence for the region and phytolith data from the Koster Site, Illinois, indicate a drying trend west of the Appalachians. However, pollen data from Delaware and from the far southern Appalachians and the Gulf Coast indicate increased rainfall along with warming during the later Hypsithermal, after 6000 B.P. Phytolith data from Neuse Levee reflect a similar increase in rainfall after 7200 B.P. but before 3800 B.P., serving to fill in the gap between areas to the north and to the south. By Early Woodland times, the climate reverted to drier conditions.

The phytolith data also provide what must be considered a false signature for the presence of domestic maize. The standard protocols used to argue for early appearance of domestic maize in other regions, when similarly applied to Neuse Levee, suggest that North Carolina was one of the very earliest regions to receive domestic maize. This proposition has no credibility. Moreover, it has now been demonstrated that the so-called maize signature may appear when maize is present, but also sometimes appears when maize is absent, and may fail to appear when maize is certain. The only conclusion to be drawn is that current maize identification phytolith typology lacks the scientific precision and accuracy necessary for effective application in archaeobotanic research. All reports of the presence or absence of maize based on these protocols must be considered equally suspect.